Quantifying the Optical Depth of Mixed-Phase Clouds Accurately with Passive Observations

Contributors
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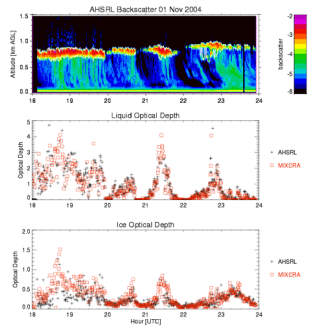
Research Highlight

Mixed-phase clouds, or clouds that contain both water droplets and ice particles in the same contiguous cloud, are difficult to characterize quantitatively with remote sensors. The lack of accurate cloud property data for these clouds hinders the ability of the scientific community to model these clouds, their interactions with the surrounding environment, and their lifetimes. Mixed-phase clouds occur frequently over the ARM Climate Research Facility (ACRF) site at Barrow, Alaska, and thus the ARM data collected at this site may help understand these cloud types. In particular, the data from the Atmospheric Emitted Radiance Interferometer (AERI) can be used to retrieve properties of mixed-phase clouds. The AERI-based mixed-phase retrieval algorithm, called MIXCRA, has been extensively validated in single-phase clouds (i.e., ice-only or water-only clouds) but had not been validated yet in mixed-phase clouds.

In the autumn of 2004, the ARM Program conducted the Mixed-Phase Arctic Cloud Experiment (M-PACE) at Barrow and over northern Alaska. One of the objectives of this experiment was to better characterize mixed-phase cloud properties and processes. One of the unique instruments deployed during M-PACE was the new polarization-sensitive Arctic High Spectral Resolution Lidar (AHSRL). Unlike most typical lidars, the AHSRL measures extinction profiles directly (most lidars require significant assumptions in order to provide extinction profiles). The polarization sensitivity was used to identify portions of the mixed-phase cloud that were dominated by ice and water, and the AHSRL's extinction profile was integrated over each phase to provide optical depths for both the liquid and the ice components of the mixed-phase cloud. These directly measured values were compared against the MIXCRA optical depths retrieved from the AERI observations for thousands of simultaneous measurements. The agreement between the MIXCRA-retrieved mixed-phase optical depths from the AERI and the AHSRL was excellent, with sensitivities that were less than 5% different.

This validation of the AERI-based MIXCRA optical depth results is important because the AERI is the only instrument capable of providing accurate optical depths in mixed-phase clouds for a large portion of the ARM data record at the Barrow site, since the site did not have a polarization sensitive lidar until 2004. Thus, this study allows the longer AERI data record to be analyzed with confidence to investigate the optical properties of mixed-phase clouds over the nearly decade of data collected at this site.



AHSRL and MIXCRA data at the ACRF Barrow site on 1 Nov 2004. The top panel shows the unattenuated backscatter observed by the AHSRL, with clouds dominated by liquid in red and ice precipitation falling from these liquid layers. The middle and bottom panels show the AHSRL measured and MIXCRA retrieved optical depths for the liquid and ice components, respectively, and qualitatively illustrate the agreement between the two different techniques.

Reference(s)

Turner, D.D. and E.W. Eloranta, 2008: Validating mixed-phase cloud optical depth rerieved from infrared observations with high spectral resolution lidar. IEEE Geosci. Remote Sens. Lett., 5, 285-288, doi:10.1109/LGRS.2008.915940.

Working Group(s)

Radiative Processes